

Non-CO₂ Greenhouse Gases: High-GWP Gases

Source/Sectors: Substitution of ODS/Industrial Process Refrigeration

Technology: Alternative systems (C.1.1.8.2)

Description of the Technology:

Alternative systems use CO₂, ammonia, hydrocarbons or a combination of these as refrigerants in place of HFC refrigerants for industrial process refrigeration applications. These systems are comparatively new but have high energy-efficiency potential. Although studies are underway, experts believe that the systems can be further improved, for both low and medium temperature refrigeration, by adapting better system designs (IEA, 2003).

Effectiveness: Good

Implementability: Potentially applicable to all regions

Reliability: Early stage of development; safety concerns associated with this option remain.

Maturity: Many new technologies designed to use these alternative refrigerants are currently at the stage of experimental tests and design improvements (IEA, 2003). Some CO₂ systems are commercialized and in use (IEA, 2003).

Environmental Benefits: HFCs emission reduction

Cost Effectiveness:

Technology	Lifetime (yrs)	MP (%)	RE (%)	TA (%)	Capital cost	Annual cost	Benefits
Alternative systems ¹	15	-	100	2-9	\$188.10	-\$1.41	\$2.76

Note: MP: market penetration; RE: reduction efficiency; TA: technical applicability; costs are in year 2000 US\$/MT_{CO₂-eq.}

1: IEA (2001) & IEA (2003)

Industry Acceptance Level: A growing number of applications are adopting such alternative systems in many countries, especially in Europe.

Limitations: There are many uncertainties remain due to the immaturity of these alternatives such as: safety, cost of designing, total cost performance, purchasing equipment, potential loss of operational efficiency and indirect emission impacts, refrigerant containment, long-term reliability, and compressor performance (IEA, 2003).

Sources of Information:

1. California Energy Commission (2005) "Emission Reduction Opportunities for Non-CO₂ Greenhouse Gases in California", a report prepared by ICF Consulting for California Energy Commissions, CEC-500-2005-121, July 2005.
2. International Energy Agency (2001) "Abatement of Emissions of Other Greenhouse Gases - Engineered Chemicals", Report Number PH3/35, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, February 2001.

3. International Energy Agency (2003) "Building the Cost Curves for the Industrial Sources of Non-CO₂ Greenhouse Gases", Report Number PH4/25, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, October 2003.
4. Kruse, H. (1996) "The State of the Art of Hydrocarbon Technology in Household Refrigeration", *Proc. International Conference on Ozone Protection Technologies*, October 21-23, Washington, D.C.
5. Mathur, G.D. (1996) "Performance of Vapor Compression Refrigeration System with Hydrocarbons: Propane, Isobutane, and 50/50 Mixture of Propane/isobutane", *Proc. International Conference on Ozone Protection Technologies*, October 21-23, Washington, D.C.
6. Paul, J. (1996) "A Fresh Look at Hydrocarbon Refrigeration: Experience and Outlook", *Proc. International Conference on Ozone Protection Technologies*, October 21-23, Washington, D.C.
7. Sand, J.R.; Fischer, S.K.; Baxter, V.D. (1997) "Energy and Global Warming Impacts of HFC Refrigerants and Emerging Technologies". Prepared by Oak Ridge National Laboratory for Alternative Fluorocarbons Environmental Acceptability Study and U.S. Department of Energy, Oak Ridge, TN.
8. U.S. Climate Change Technology Program (2005) "Technology Options for the Near and Long Term", U.S. Department of Energy, <http://www.climatechange.gov/index.htm>, August 2005.
9. U.S. Environmental Protection Agency (2001) "U.S. High GWP Gas Emissions 1990 – 2010: Inventories, Projections, and Opportunities", Office of Air and Radiation, U.S. Environmental Protection Agency, EPA 000-F-97-000, June 2001.
10. U.S. Environmental Protection Agency (2004) "Analysis of Cost to Abate Ozone-depleting Substitute Emissions", Office of Air and Radiation, U.S. Environmental Protection Agency, EPA 430-R-04-006, June 2004.
11. U.S. Environmental Protection Agency (2006a) "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2004" Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-002, June 2006
12. U.S. Environmental Protection Agency (2006b) "Global Mitigation of Non-CO₂ Greenhouse Gases", Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-005, June 2006.
13. UNEP - United Nations Environment Programme (1998) "Report of the Refrigeration, Air Conditioning and Heat Pumps", Technical Options Committee; Nairobi, December 1998.
14. van Gerwen, R.; Vervoerd, M. (2000) "Emission reduction of non-CO₂ Greenhouse Gases Used as Refrigerants" in *Non-CO₂ Greenhouse Gases: Scientific Understanding, Control and Implementation* (edited by J. Van Ham *et al.*), Kluwer Academic Publishers, London.
15. Walker, D. (2000) "Low-charge Refrigeration for Supermarkets", IEA Heat Pump Center Newsletter, vol. 18, no. 1, p. 13-16.